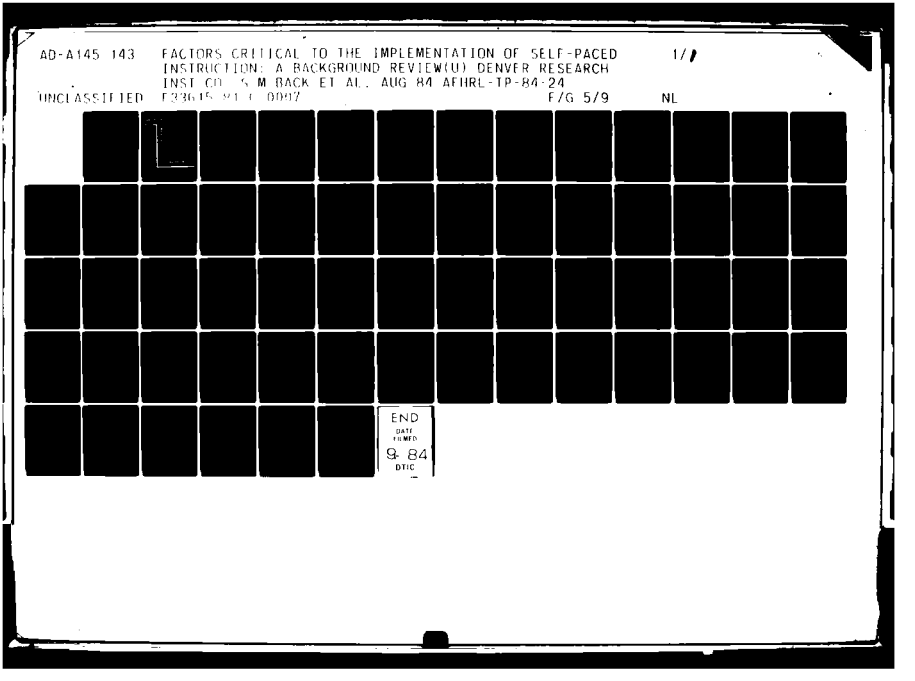
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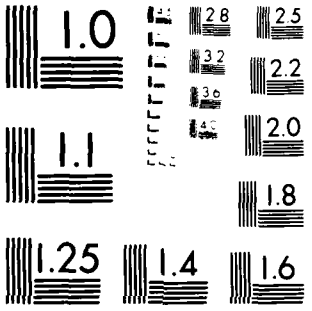

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FACTORS CRITICAL TO THE IMPLEMENTATION OF SELF-PACED INSTRUCTION: A BACKGROUND REVIEW

By

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AIR FORCE SYSTEMS COMMAND
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In a previous effort ~~(AFHRL-TP-84-23)~~, the literature pertaining to self-paced instruction was initially collected and reviewed to support a study of factors associated with the successful utilization of self-paced instruction in Air Force technical training. The purpose of this technical paper is to provide a more in-depth analysis of the literature relevant to the findings of that study. In general, the analysis of the literature revealed a high level of consensus among military and civilian reports with respect to factors associated with successful implementation of self-paced instruction. In addition, the findings based on this literature review are generally in agreement with results derived from the case studies reported in AFHRL-TP-84-23.

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SUMMARY

This is the second of two technical papers resulting from a study of the factors associated with the successful utilization of self-paced instruction in Air Force technical training. The first paper (McCombs, Back, & West, 1984) focused on critical factors derived from the literature and case studies of selected Air Force courses using a variety of self-paced formats (e.g., programmed texts, audiovisuals, computer-assisted instruction). Critical factors were defined as those variables which markedly affect both the real and perceived effectiveness of self-paced instruction, as well as user acceptance of self-paced instruction as a viable instructional method.

The literature pertaining to self-paced instruction was initially collected and reviewed to support the critical factors research. The decision was later made to examine the literature more analytically in terms of how well it supports the concept that particular factors, in combination, are critical to the success or failure of self-paced instruction in Air Force technical training. The purpose of the present paper, then, is to provide a more in-depth analysis of the literature relevant to study findings, in an attempt to extend the generalizability of these findings. Information is provided on each reference cited, including whether it was conceptual or empirical in nature and whether it addressed a military or civilian population. The literature is organized into Management and Instructional factors found to be particularly important in the Air Force technical training context.

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INTRODUCTION

Background

The success or lack of success of self-paced instruction has been attributed to many diverse factors in both the civilian and military literature. The study by McCombs, Back, and West (1984) attempted to isolate and examine systematically those factors most critical to the success or nonsuccess of self-paced instruction in the context of Air Force technical training. The major finding in this study was that no single factor is predominantly responsible for the success or nonsuccess of self-pacing, but that a combination of factors appears to make the difference. The factors that in combination contributed most to the success or nonsuccess of self-pacing in the technical training context are visually represented in Figure 1.

The underlying concept represented in Figure 1 is that for self-pacing to be successful, it must be perceived to be cost effective. That is, instructor and management personnel must perceive that the method is contributing to the cost efficiency of training and/or producing quality graduates in terms of training standards and criteria. In turn, this perception is based on the presence of high instructor dedication and motivation and on indications that the method is adequately meeting student needs. These latter two factors operate singly as well as in combination (implying good communication between management and instructional development personnel). Finally, to the extent the various management and instructional factors are present, working well together, and producing perceptions that the self-paced method is cost effective, these perceptions will positively influence the stability of the management and instructional factors.

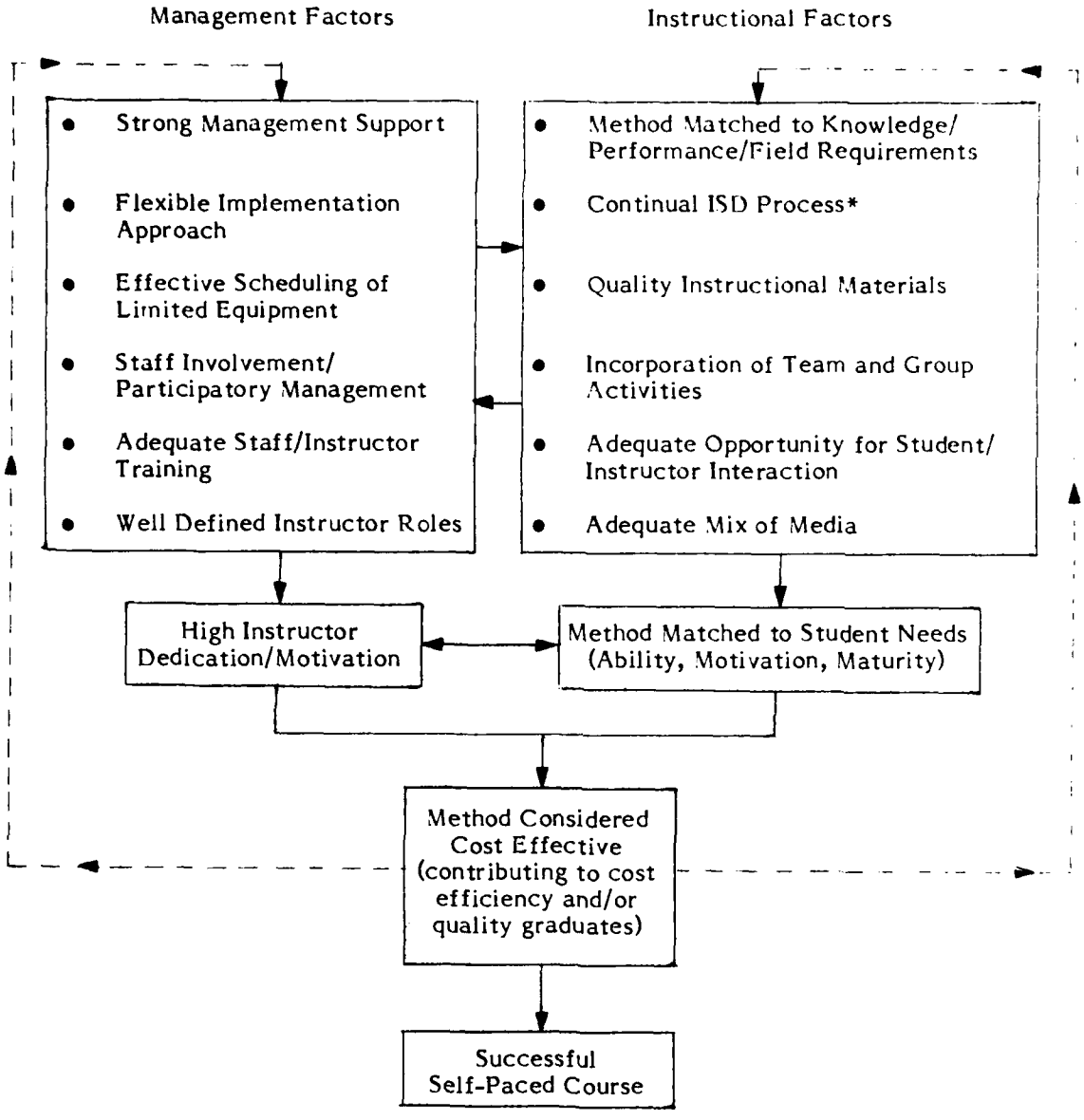
The factors found to be critical to the success of self-pacing in the Air Force technical training context included many key factors identified in a preliminary literature review. The question arises, however, whether the literature can provide more general support for the concept that particular factors, in combination, are critical to the success or nonsuccess of self-pacing. This paper focuses on this question in an attempt to extend the generalizability of study findings. Thus, the literature base for this study has been reanalyzed and organized around the critical factors shown in Figure 1, and around the issue of whether these particular factors appear to operate in combination in determining the success or lack of success of self-pacing.

Definitions

As an introduction to issues and factors surrounding the success or lack of success of self-pacing, this section briefly reviews definitions of key concepts and terms related to self-paced instruction. For example, the term "self-paced instruction" is often used interchangeably with "individualized instruction" or in conjunction with "programmed instruction," "computer-aided instruction," and "computer-managed instruction."

Zajkowski, Heidt, Corey, Mew, and Micheli (1979) have defined the various terms used in this field as follows:

> Individualized Instruction (II). An instructional strategy in which all learning activities are designed to accommodate individual



*Instructional Systems Development--a four-step Air Force process to systematize the development and evaluation of training materials.

Figure 1. Combination of factors critical to the success of self-pacing in Air Force technical training.

differences in background, skill level, aptitudes, and cognitive styles. Individualized Instruction is characterized by the following attributes:

- releasing of time constraints
- choice of instructional media
- instruction adjusted to skill levels and learner characteristics. It often employs programmed instruction.

Programmed Instruction (PI). An instructional format which presents individualized materials in a sequence of small units, each of which requires an immediate response from the trainee and which also provides the trainee with immediate knowledge of results.

Computer-Aided Instruction (CAI). An instructional delivery medium in which a computer system is used to provide instruction and where there is an ongoing interchange of stimulus and reaction between the computer and trainee. When a CMI capability coexists within the host computer system, the computer system serves both a media and management function.

Computer-Managed Instruction (CMI). An instructional management system in which a computer is employed to prescribe a series of instructional materials for individual trainees. Usually associated with II, it may include the capability for record keeping, testing, counseling, and the selection of various media for the delivery of instruction. (p. 11-12)

Individualized instruction may be manually prescribed and managed by an instructor or automatically prescribed and managed by a computer. The primary instructional delivery medium that employs programmed instruction is the programmed instruction text. Individualization within this medium is provided by self-pacing and, in some cases, response-contingent branching. Computer-aided instruction and computer-managed instruction may be implemented within a self-paced or group-paced format.

The preceding methods of instruction are contrasted with conventional methods of instruction (combinations of lectures, discussions, laboratory, and tutorial sessions) which are group-paced rather than individually paced, as well as with nonvariant media and instructional sequences (Orlansky & String, 1979; Zajkowski et al., 1979). Conventional instruction is also referred to as lockstep instruction, platform instruction, and group-pacing.

Self-paced instruction, because of its close alliance with individualized instruction and programmed instruction, builds on many of the theoretical principles associated with the effective implementation of these instructional technologies. Hartley (1972) cited the need for

- analysis of the material to be taught and tasks to be learned;

- specification of prior knowledge, skills, and abilities of students; and
- behaviorally stated, measurable objectives.

Jacobs, Maier, and Stolurow (1966) added the following:

- making all instruction goal oriented;
- organizing the instruction into an effective sequence;
- presenting one point at a time;
- actively involving the student in the learning process;
- giving immediate knowledge of results; and
- allowing each student to proceed at his or her own pace.

Another feature of manual and computerized self-paced instruction is that it can be either linear or branched (O'Day, Kulhavy, Anderson, & Malczynski, 1971):

> If every learner follows the identifical sequence, that is, if the frames are encountered in a single, prearranged order, the program is described as linear. On the other hand, if on most of the frames the particular response emitted by the learner determines which of several alternative frames he proceeds to next, the program is described as branching. If the learner emits the correct response on a branching program, he will be directed to the next frame in the correct answer sequence. On the other hand, if he emits an incorrect response, he will be directed to a remedial frame or to a sequence of remedial frames before being returned to the correct answer sequence. (p. 5)

History of Self-Pacing

The event commonly credited with initiating the development of the "programmed instruction" method of self-pacing was the presentation of a paper by B. F. Skinner in 1954, entitled "The Science of Learning and the Art of Teaching," and its subsequent publication in the Harvard Review (Atkinson & Wilson, 1969; Corey, 1967).

Some researchers would argue that instructional programming dates back to antiquity. "Several writers have pointed out that Socrates in the Meno taught a slave boy the proof of the Pythagorean theorem by using simple diagrams and leading the boy by small steps to generalizations of some significance" (Corey, 1967, pp. 24-25). Mechanized teaching machines first appeared in 1915, when Sidney L. Pressey designed a teaching machine which could present material, require a response, and provide reinforcement, as well as administer and score multiple-choice examinations. Pressey eventually abandoned his efforts, recognizing that he was ahead of his time (Kulik, Cohen, & Ebeling, 1979).

According to Branson (1977), "World War II created a sudden need to increase dramatically the effectiveness and efficiency of military training" (p. 355). Likewise,

Olsen and Bass (1982) cite the Second World War as providing impetus to the development of training techniques and devices, including the use of film and overhead projectors. By the late 1950s, the Air Force was conducting extensive work in programmed instruction at Keesler Air Force Base using Auto Tutor Mark I teaching machines (Olsen & Bass, 1982).

In December 1958, the Air Force Office of Scientific Research and the University of Pennsylvania sponsored a conference on Automated Teaching of Verbal Symbolic Skills. Soon thereafter, the Army's Human Resources Research Office and the Office of Education began to sponsor projects in the area of automated teaching (Olsen & Bass, 1982). Since then the National Science Foundation and the Federal agencies formed as a result of the Elementary and Secondary Education Act of 1965 have played a major role in the development of self-paced instruction (Arthur D. Little, Inc., 1979; Atkinson & Wilson, 1969; Corey, 1967).

In February 1962, a meeting was held at Randolph Air Force Base for the purpose of founding the National Society for Programmed Instruction (NSPI), the goal of which was to "collect, develop and diffuse information concerned with programmed instruction" (Ofiesh & Meierhenry, 1964, p. v). The original group represented a cross-section of San Antonio military, public school, and university officials. In April 1962, NSPI presented the first Programmed Instruction Institute at which Ofiesch outlined three nationwide problems facing education at that time: high school dropouts, industrial retraining, and teacher procurement. It was suggested that programmed instruction could be a first step toward partial solution of these problems (Ofiesh & Meierhenry, 1964). Other influences cited as contributing to technological innovations in education during this time period included reaction to the Soviet launching of Sputnik and the late President Kennedy's message to Congress that no task is more important to our nation than expanding and improving educational opportunities for everyone (Ofiesh & Meierhenry, 1964).

An important factor contributing to the growth of that type of self-paced instruction known as computer-assisted instruction (CAI) has been the rapid development of electronic data processing. Specifically, the introduction of time-sharing systems, the invention of the integrated circuit, and the design and production of third-generation computers have provided a major impetus to CAI (Arthur D. Little, Inc., 1979; Atkinson & Wilson, 1969). For example, while the PLATO I system at the University of Illinois originally could handle only one student terminal at a time, subsequent development of time-sharing and central processing capabilities has resulted in a system that can support 950 terminals linked through microwave and land-line communications to a large central computer.

Industry's involvement in the design and production of totally integrated hardware-software systems also was influential in the rapid growth of CAI. IBM, Control Data Corporation, and Philco-Ford were leaders in this endeavor (Arthur D. Little, Inc., 1979; Atkinson & Wilson, 1969). Equally important to the development of hardware and time-sharing systems is the development of instructional programs (i.e., curricula). Several major publishers have entered this arena either alone or in collaboration with hardware manufacturers (Atkinson & Wilson, 1969).

Universities saw CAI as having the potential to meet the educational needs of their students, save instructional time, and allow more flexibility in teaching. With funding from the Carnegie Foundation and the U.S. Office of Education, Stanford

University was able to develop experimental tutorial lessons in reading and mathematics. Public schools became interested in CAI because of its capacities for self-paced learning, branching and monitoring of student progress (Arthur D. Little, Inc., 1979; Atkinson & Wilson, 1969).

As early as 1959, the development of computer-assisted instruction was important to the Government as a possible means of training its military personnel (Arthur D. Little, Inc., 1979). Both the U.S. Office of Education and the National Science Foundation supported research projects concerned with (a) teaching the sciences quickly and effectively and (b) understanding learning and perception. CAI research was funded by the Army (Signal Corps and Ordnance Corps), the Navy (Office of Naval Research), and the Air Force (Office of Scientific Research, Air Research and Development Command). "CAI was such a major priority, that the government was willing to expend whatever was necessary to accomplish a full understanding of the merits of CAI and its possible applications" (Arthur D. Little, Inc., 1979, pp. I-13).

In January 1962, the U.S. Air Force Air Training Command began an 18-month experiment in developing programmed instruction. Most of the resulting packages involved self-pacing. In August 1965, self-pacing was first implemented in the administrative specialist course (Canfield, 1966; Goldman, 1982).

The early experimental stage of CAI was followed by a commercial stage of CAI diffusion, beginning in 1965. Throughout this commercial stage, the Federal Government, particularly the military, was a major user and funder of CAI systems. CAI technology has allowed mass military personnel training in logistics, finance, equipment maintenance, leadership, management, and tactics, as well as other fields. "CAI was advantageous to the government in that it relieved much of the burden of military academic training. Training has been more efficient and less time consuming, and trainee comprehension has improved" (Arthur D. Little, Inc., 1979, pp. I-19).

Despite the promising beginning of self-paced instruction and, in particular, CAI, many applications have not achieved realization. The present literature review focuses on factors related to the success or nonsuccess of self-paced instruction, primarily CAI. This joint consideration is due to the fact that relatively little literature is available on self-paced instruction in the absence of computerization.

The following sections briefly review two instructional technologies which have historically been integrated with self-pacing and which influence its success or nonsuccess: criterion-referenced testing and the instructional systems development (ISD) process.

Self-pacing and criterion-referenced testing. With the advent of self- paced instruction in the military, there was a shift away from norm-referenced testing to criterion-referenced testing (Orlansky & String, 1981; Training Developments Institute, 1980). In a report prepared for the Army on the effectiveness of self-paced instruction, the Training Developments Institute (1980) described the relationship between self-paced instruction and criterion-referenced testing as a result of an assessment of problems with training:

> It is a well-known fact that one learns best by performing. However, typical Army training in the past has been highly instructor centered. The instructor would lecture for a few hours with the student in a passive mode. This was generally followed by a practical exercise (PE) which usually failed to cover all tasks previously presented and did not always involve all students. Programs of Instruction (POI) stated explicitly the time scheduled for the PE, but this did not mean each student individually practiced that amount of time.
>
> What actually happened was one student performed the task, one student perhaps read aloud the procedures from the technical manual, while the remaining students supposedly watched the procedures from a distance in preparation for their turn . . . . The students could in no way become proficient if there was not sufficient job relevant performance oriented training for each individual.
>
> By contrast, using an individualized, self-paced mode of instruction, the student spends all of his [sic] PE time practicing the job relevant tasks. The student first works through an interactive lesson which explains the procedures to him. Then he practices what he has just learned. Further, every student performs the task individually and is required to be competent on each task. Therefore, in this regard, the self-paced mode of instruction is many times more effective than the traditional lock-step method. (pp. I-5, I-6)

Utilization of criterion-referenced testing requires a task analysis which results in precisely stated job performance measures for each task. The job performance measure forms the basis from which lesson objective standards and criterion test items are derived. In many cases the job performance measure and the lesson standards are identical; in others the lesson standards are lower or modified because it would be impractical to perform the task to the job standard (Training Developments Institute, 1980). Testing on job tasks on an actual system or on a simulator was recommended by Koch, Englert Vestewig, and Larson (1981) in a paper on Army training presented at a military conference.

Two characteristics of successful self-paced courses cited by Hungerland (1979) are (a) having a performance orientation (i.e., evaluating proficiency by the student's ability to perform tasks that make up the job rather than to achieve certain test scores), and (b) having an absolute criterion of 100 percent. This study of two courses was conducted as part of the Army's effort to institute self-paced instruction systematically within a job performance approach.

Criterion-referenced testing was advocated by IBM in Dean's (1977) nonempirical paper presented at the Annual Conference of the Association for the Development of Computer-Based Instructional Systems, and subsequently published in the Journal of Computer-Based Instruction. In a review of the literature on the education of elementary age children, Wang (1980) also recommended criterion-referenced testing as well as criterion-referenced assessment:

> Criterion-referenced assessments, that is, indices designed to determine the presence and absence of certain specific competencies, used in the context of adaptive instruction, provide teachers with the necessary information to determine skills and knowledge already possessed by students so that their appropriate entrance into the learning sequence can be insured. Furthermore, the use of such clear-cut descriptions of the students' capabilities insures that they neither repeat tasks that they have already mastered nor work on objectives for which they lack critical prerequisites. (p. 4)

Related to the issue of criterion-referenced testing is the need to state learning outcomes in terms of performance objectives. References to this need can be found in both the civilian and military literature.

In a nonempirical chapter concerning civilian instruction, Corey (1967) emphasized the need to formulate objectives. Gibbons, Axtell, and Hughes (1981) were more specific. As part of a series of developmental reports prepared for the Air Force on the design and development of an instructional system for F-16 personnel, they cited the need for criterion-referenced objectives. In a nonempirical paper published in a civilian journal, Stolurow (1972) emphasized the need to formulate objectives and criterion-referenced test items.

Montemerlo and Harris (1978) warned against overly specific behavioral objectives. In a theoretical paper prepared for the U.S. Air Force Academy, they concluded:

> It is neither possible nor desirable to break down the over-all objectives of a training program to an extremely large number of atomistic specific behavioral objectives (SBO). SBOs should be used for guiding course design and should not become overly voluminous .... The definition of training objectives is not a straightforward procedure. It is likely to be the most heart-rending portion of course design. The simplest, cheapest, and most circular method of determining what should be taught is to ascertain from existing course documentation what is taught. Actually going to the field to determine what skills should be taught is expensive, time-consuming and usually frustrating because the subject matter experts (SMEs) can't agree .... The most important skills to be learned for any job are impossible to define precisely. They include the ability to generalize from what has been learned to whatever may arise on the job. Psychologists refer to this as "learning how to learn" or "generalized transfer of learning." An excellent method of learning about the problems inherent in the definition of training objectives is to review the nonsuccesses, the tribulations, and the false starts as well as the successes of others. (p. 4)

Self-pacing and the ISD process. Instructional Systems Development (ISD) is a systematic process whereby approved procedures and techniques are applied in the development and conduct of training (Zajkowski et al., 1979). The need for an adequate ISD process prior to initiation of course changes has been noted in the military literature

(Berkowitz & O'Neil, 1979; Plocher, Miller, Gardner, & Cronin, 1977; Vineberg & Joyner, 1980). In the late 1960s, the systems approach to the design and management of instructional systems was receiving increased attention in the Department of Defense. In 1970, the Air Force issued Regulation 50-2, Instructional Systems Development, which outlined a step-by-step model for instructional design for all Air Force courses. This regulation was subsequently updated in 1975 and 1979 (Olsen & Bass, 1982).

In an assessment of individualized instruction in Navy technical training, Zajkowski et al. (1979) state that the history of individualized instruction in the Navy is inextricably interwoven with the implementation of the systems approach to the design and management of training and with research and development in programmed and computer-aided instruction. According to Olsen and Bass (1982), however, the Navy "has only a small cadre of qualified instructional designers and only a few courses ISDed" (p. 36).

The Army's first attempt at instructional systems development took place in the 1960s and was known as systems engineering. More recently, the Army has attempted to provide standardized procedures for the development and conduct of training in accordance with the Interservice Procedures for Instructional Systems Development Model (Training and Doctrine Command, 1975). This model provides for the assessment of training needs, the design, development, and implementation of instruction, and the assessment of instructional quality through a five-phase process (Berkowitz & O'Neil, 1979):

> The first phase is ANALYZE, which provides guidance on task analysis, the selection of tasks to be trained, the development of measures of job performance and the selection of the appropriate environment for training. DESIGN is the second phase which establishes the test objectives, test items, and sequence of the course. The entry behavior or skills the trainee arrives with are also noted during this phase. The third phase is DEVELOPMENT during which the instructional materials are created. Existing materials are examined so that new course materials are devised only when appropriate others do not exist. A plan specifying all activities of the learner is made as well as a plan for pilot testing the newly developed materials. During IMPLEMENTATION, Phase IV, the plan of Phase III is activated with particular attention to the personnel needed to accomplish the plan. The quality of the instruction is assessed during Phase V CONTROL in terms of new skills acquired by the trainees and the fulfilled needs of the command. (pp. 1-3)

The civilian literature cites the need for activities comparable to the ISD procedure. These include conducting a task analysis (Kearsley, 1977a; Rogers, 1982), specification of goals and objectives (Cohen, 1981; Hartman & Garnett, 1981; Lange, 1967; Rogers, 1982; Shuell, 1978), and systematic instructional design (Kearsley, 1977a; Lange, 1967; Lindvall & Bolvin, 1967; Rogers, 1982; Roblyer, 1981; Shuell, 1978). Likewise, the military literature advocates a systematic instructional design approach (Freda, 1980; Freda & Shields, 1980; Montemerlo & Harris, 1978; Olsen & Bass, 1982), and precise statement of job performance measures (Training Developments Institute, 1980).

In a handbook on the design of instruction prepared for a general audience, Briggs and Wagner (1981) advocated a "systems approach" to the design of instruction. Likewise, a systems approach was recommended by Kearsley (1977a) in a paper prepared for the U.S. Department of Health, Education and Welfare, National Institute of Education; by Lindvall and Bolvin (1967) in a theoretical book chapter on programmed instruction; by Roblyer (1981) in a theoretical paper; by Rogers (1982) in a nonempirical journal article for educators; and by Shuell (1978) in a theoretical review article which was presented at an education conference.

The systems approach results in a model to be followed that ensures all components will fit each other; that is, the objectives, the teaching and the testing of learner achievement will all be congruent. Furthermore, components will be analyzed and developed in a planned sequence (Briggs & Wagner, 1981). Sequencing the units of instruction was advocated by Corey (1967) in a theoretical chapter prepared for a general education audience. In the same book, Lange (1967) emphasized the need for a "systems approach," which was defined as an integrated set of procedures in instructional development.

Unfortunately, shortcomings in the ISD process are often confused with the mode of instruction employed. The result has been that in some cases self-pacing has been blamed for what is essentially an ISD problem. In a report published by the Training Developments Institute (1980) assessing the effectiveness of self-paced courses in the Army, it is concluded that for training to be effective, (a) the task list must be constrained to those tasks which are critical, (b) the student must receive job relevant and performance-oriented training, and (c) the tests must be criterion-referenced to ensure that students have attained the skills required for the job. These factors are regarded as crucial whether the course is lockstep or self-paced. A further discussion of ISD factors related to the success or nonsuccess of self-pacing is presented in the section on Instructional Factors.

Summary

The implementation of self-paced instruction has resulted in a multitude of sophisticated formats of instruction and an extensive theoretical and empirical literature. Accompanying these technological advancements available to education, has been a shift from norm-referenced to criterion-referenced testing and the application of a systems approach to curriculum development. The general consensus in the literature is that adequate self-paced instruction requires a complete task analysis, specification of goals and objectives, systematic instructional design, and performance-based evaluation. An understanding of this background for self-paced instruction provides a framework for understanding management and instructional factors cited as important to the success of self-pacing.

MANAGEMENT FACTORS

A number of factors related to the implementation and management of a self-paced course were found to be critical to the success of self-pacing in Air Force technical training (McCombs, Back, & West, 1984). Literature relevant to these factors is reviewed in this section (see Figure 1).

Strong Management Support

In the McCombs, Back, and West (1984) study, strong management support was defined as the presence of strong support for the self-paced method among course and upper management personnel. That is, personnel at the local and upper management levels favored the self-paced method over conventional methods of training and expressed support for this method from a fiscal, resource, and attitude standpoint. Management support has been cited as one component of successful adoption of innovation in the technology transfer literature.

The Process of Technology Transfer

The content and process of technology transfer have received considerable attention in the scientific literature and there has been some application to the field of education. Technology transfer has been defined as the art of moving technology from its place of origin into various applications (Johnson, 1981). In a theoretical paper, Pelz and Munson (1980) postulated four stages in the process of organizational innovating:

- Diagnosis is the translation of a sense of unease into a problem so that action toward solving it may be undertaken.
- Design is the development, adaptation or borrowing of an innovative solution.
- Implementation is the stage in which the innovation is put into place.
- Stabilization is the period in which the innovation becomes an integral part of the organization. This stage is not reached in all transfers.

Variations on these stages have been described by others. Freda (1980) has outlined a four-step systems model of technology transfer in military training: (a) analysis of requirements; (b) research, development, test and evaluation of solutions; (c) dissemination of findings; and (d) institutionalization. Within these steps specific issues include analysis of needs, consideration of appropriateness of funding, user acceptance, transition from innovation to policy, prediction methodology and recommendations for ongoing monitoring, evaluation and feedback.

Effectiveness of Technology Transfer

In what is now a landmark theoretical paper on innovation adoption, Downs and Mohr (1976) described the area as "beyond interpretation" (p. 700). Variables found to be important for one innovation are not important at all or even inversely important for another. Bingham, Freeman, and Felbinger (no date) authored an unpublished manuscript for the National Science Foundation which combined a theoretical analysis, a review of research on innovation adoption and a computer analysis of the process of innovation adoption by city governments. The authors agreed with Downs and Mohr's conclusion that there is no single theory of innovation but different theories explaining different aspects of innovation. Downs and Mohr (1976) further proposed that the unit of analysis should not be the adoption but rather the decision to adopt. Bingham, Hawkins, Frendreis, and LeBlanc (1978) also emphasized the importance of studying why the choice to innovate was made and in what context it occurred.

Not all students of technology transfer concur with Downs and Mohr. Rogers and Shoemaker (1971) have suggested five general innovation characteristics which affect implementation: relative advantage, compatibility of an innovation with existing values and needs, complexity, trialability and observability. Of these characteristics, complexity was found by Rogers and Shoemaker to have a negative relationship with innovation adoption; all others were suggested to have a positive relationship. In a review and meta-analysis of several innovation characteristics research studies, Tornatzky and Klein (1982) concluded that the empirical findings were not as unstable as Downs and Mohr suggested. Tornatsky and Klein found that perceived characteristics such as relative advantage, complexity, and compatibility were consistently related to adoption and implementation across a variety of technologies and settings and that primary characteristics of innovations can be operationalized even in cases in which the technology is social rather than material. The following paragraphs describe the characteristics of technology transfer reviewed by Tornatzky and Klein (1982), together with the results of their secondary analysis.

Compatibility, defined by Rogers and Shoemaker as "the degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of the receivers," (1971, p. 145), was the most frequently cited characteristic in the studies reviewed. The secondary analysis showed a positive, though not always statistically significant, relationship between the compatibility of an innovation and its adoption. Tornatsky and Klein (1982) caution, however, that the strength of this conclusion is limited by the fact that some of the studies measured practical compatibility; some, value compatibility; and some, a combination of the two.

Relative advantage, defined by Rogers and Shoemaker as "the degree to which an innovation is perceived as being better than the idea it supersedes" (1971, p. 138), was found in the meta-analysis to be positively related to adoption.

Complexity, defined by Rogers and Shoemaker as "the degree to which an innovation is perceived as relatively difficult to understand and use" (1971, p. 154), was found to be negatively related to an innovation and its adoption.

Cost, which is usually assumed to be negatively related to the adoption and implementation of an innovation, was found to be positively related to adoption in three studies and negatively related in two.

Communicability, defined by Rogers and Shoemaker as the degree to which aspects of an innovation may be conveyed to others, is usually presumed to be positively correlated with adoption and implementation. The studies reviewed did not permit direct statistical comparison of this relationship.

Divisibility, defined by Fliegel, Kivlin, and Sekhon, in a study of innovation in agriculture, as the "extent to which an innovation can be tried on a small scale prior to adoption" (1968, p. 446), was not found to have a consistent relationship with adoption.

Profitability, defined by Tornatzky and Klein as the level of profit to be gained from adoption of the innovation, is usually assumed to be positively correlated with adoption and implementation. Of the four studies providing first-order correlation data, however, three found profitability to be negatively (albeit nonsignificantly) related to adoption.

Social approval, defined by Tornatzky and Klein as status gained in one's reference group, was not found to have a statistically conclusive relationship to adoption.

Trialability, defined by Rogers and Shoemaker as "the degree to which an innovation may be experimented with on a limited basis" (1971, p. 155), is presumed to be related to more frequent and quicker adoptions. The studies reviewed, however, did not permit direct statistical comparison of this relationship.

Observability, defined by Rogers and Shoemaker as "the degree to which the results of an innovation are visible to others" (1971, p. 155), is presumed to be positively correlated with rate of adoption. No overall relationships are reported by Tornatzky and Klein (1982).

As noted by Downs and Mohr (1976), any study of an adoption process must begin with an examination of the decision to adopt. In the research paper prepared for the Air Force by McCombs, Back, & West (1984), imposition of design criteria by an outside team was cited as a major factor in the nonsuccess of self-paced instruction (Gissing, 1982). Both the civilian literature (Lippey, 1975; Plato, 1981; Wolcott, 1981) and the military literature (Freda, 1980; Freda & Shields, 1980; Seidel, Rosenblatt, Wagner, Shulz, & Hunter, 1978) support the view that implementor and user should be in agreement on project purposes.

Freda (1980) recommended identifying early adopters and opinion leaders within target audiences, developing procedures for contacting these individuals and using them to sustain the diffusion effort. Allen (1977) cited two factors as likely to increase the dissemination/acceptance of a new technology:

- Having an in-house technical specialist within the organization who can keep lines of communication open within and outside the organization. This concept of a "technological gatekeeper" is particularly important in an organization such as the Air Force Air Training Command where new technologies are being applied at the bottom of the organizational hierarchy.

- Having an "opinion leader" who formally disseminates information from higher levels of the organization to lower levels.

Some see the process of introducing an innovation as almost a "selling" task. Several authors have warned against overselling a system (Briggs, 1977; Fliegel, Kivlin & Sekhon, 1968; King, 1975; Mayo, 1975; Plato, 1981). Clayton's (1979) theoretical paper warned against the desire to establish a "market" that will depend on the donor for support.

Management Support

Once an innovation is adopted, there is a need for strong management support for its continued application. This need has been cited by Sprecher and Chambers (1980), Seidel and Wagner (1981), and Seidel et al. (1978). This support includes:

- providing adequate instructor role training (Davidson & Schmitt, 1979; Kimberlin, 1976; King, 1975; Lange, 1967; Lindvall & Bolvin, 1967; Misselt & Call-Himwick, 1978)

- reducing instructor overload through the provision of support staff and/or flexible scheduling (Caffarella, Cavert, Legum, Shtogren, & Wagner, 1980; Hartman & Garnett, 1981; Kimberlin, 1976; King, 1975; Lindvall & Bolvin, 1967; Magarrell, 1976; Montemerlo & Harris, 1978; Wilkie, 1979)

- deliberate efforts to keep instructor motivation high (Cohen, 1981; Freda, 1980; Freda & Shields, 1980; Johnson, 1974; Magarrell, 1976: Mayo, 1975; Plato, 1981; Seidel & Wagner, 1981; Sprecher & Chambers, 1980; Wolcott, 1981; Wollitzer, 1977; Zajkowski et al., 1979)

- multilevel staff orientation and training (Freda, 1980; King, 1975; Lange, 1967; Plato, 1981; Seidel & Wagner, 1981; Seidel et al., 1978; Training Developments Institute, 1980)

- provision of adequate fiscal/resource support for in-house materials development (Freda & Shields, 1980; Luskin, Gripp, Clark, & Christianson, 1972; Milner, 1979; Misselt & Call-Himwick, 1978; Montemerlo & Harris, 1978; Sprecher & Chambers, 1980)

In a study of individualized instruction in the Navy, Zajkowski et al. (1979) found that organizational structure was identified more frequently than any other factor as having a significant influence on success. Difficulties with this factor included: the complexity of the management structure; problems in integration and coordination of planning, budgeting and instructional system development processes; and the perceived absence of accountability for specified tasks.

In the Air Force, it has been noted that factors contributing to the lack of success of a CMI implementation included (a) lack of consistent high level management direction and support to integrate CBI development into consolidated thrust, and (b) inadequate resources applied to refining and translating new technologies to operational settings.

Downs and Mohr (1976) made a distinction between primary attributes of an innovation (i.e., size or cost) and secondary attributes which are perceptually based or subjective (i.e., complexity or relative advantage). Tornatzky and Klein (1982) emphasized the importance of these subjective factors in innovation adoption. For example, what may seem inexpensive to one adopter may be exorbitant to another.

Kaufman's (1982) theoretical paper on change in education suggested that utility for an organization is one of the main factors in acceptance of an innovation. For effective change to take place, innovation must "contribute to the development of useful results within and outside the organization" (Kaufman, 1982, p. 35). Here again, the subjective perception of utility may play a role in acceptance. Kaufman recommended that an innovation not be implemented if the present system is working well.

Flexible Implementation Approach

McCombs, Back, and West (1984) defined the flexible implementation approach as an approach to the management and implementation of self-pacing wherein flexible and creative solutions to problems are implemented (e.g., embedding group activities within the self-paced context). That is, the user group has not only adopted the innovative technology of self-paced instruction, but it has adapted this innovation to their particular needs.

In an investigation of implementation of innovations at 19 sites, Yin (1978) defined routinization as the process by which an innovation becomes part of the standard operating procedures of an organization. In a proposal submitted to the National Science Foundation, Davidson and Schmitt (1979) pointed out that as a program is adopted, it is often adapted. They call the extent to which the adopted program resembles the original, the "degree of implementation." Glasser and Backer (1977) conducted an informal survey of experts on planned changes, as well as a series of intensive case studies. These authors focused on the durability of an innovation and suggested that technologies which are adapted may have a greater chance of long-term survival than those which are adopted in their entirety.

The degree to which the recipient site can clearly formulate its needs is considered an important criterion for success. The value of a needs assessment prior to a transfer was noted by Hutchinson, Liebert, Lombardo, and Stivers (1978) in a User's Guide prepared for the Florida State Department of Health and Rehabilitative Services. In addition to an assessment of need, receptivity of the potential recipient is an important factor in any transfer. While formulation of needs is important for initiation of a transfer, in the actual adoption of new procedures, receptivity and the opportunity for decision making by the actors has been cited as important by Fairweather, Sanders, and Tornatzky (1974) and Rogers and Shoemaker (1971), in a book on cross-cultural communication of innovations.

In a study conducted for the National Science Foundation, Rogers, Eveland, and Klepper (1977) stated: "The process of innovation is essentially a process of specification carried out within the organization--that is, a process of increasing the specificity of definition of the innovation and its use" (p. 7). The authors designated two major categories of decisions which have to be made: (a) those relating to the innovation itself and (b) those relating to its application, (i.e., how it is to be used). Specification of the tool and of its application are parallel aspects of the innovation process. The authors also said that the process of innovation is subject to different influences at different points in time. Influences cited by Rogers et al. (1977) included:

- the degree of professionalism of the participants;
- system support, i.e., external sources promoting the innovation such as marketers and change agents;
- the general innovativeness of the organization;
- the pattern of external accountability of the organization, i.e., its acceptance of responsibility for achieving and maintaining a certain level of performance;
- the nature of resources available to the organization which could be applied to the innovation;
- the communication patterns within the organization; and
- the framework for feedback within the organization.

Based upon case studies of urban bureaucracies in areas including implementation of computer-assisted instruction, Yin (1978) offered suggestions for promoting routinization of new practices:

- There should be a designation of an innovator or innovator team who must develop agency support for the innovation and establish the appropriate skills and resources for initially operating it. Some group of agency practitioners must be trained to use the innovation and to begin using it as frequently as possible, preferably in relation to regular agency practices rather than as a special project.
- It is important to get the new practice operating on a daily basis at the outset, even if this is done by limiting its scope.
- The new practice should have concrete benefits for service practitioners, e.g., convenience, reduced physical effort, greater potential for promotions, and additional sense of safety on the job.

- Preferably the new practice should completely displace an old one and specific steps should be taken to eliminate the old way of doing business, e.g., by eliminating the old forms and procedures.

- The new practice should be expanded to its fullest logical extent, or else it will continue to be regarded as a "special project" which will preclude it from becoming a standard practice.

Writers on educational innovation and change (Fullan & Pomfret, 1977; Kaufman, 1982; Wolcott, 1981) have pointed out the importance of an innovation's meeting useful organizational goals for its successful adoption and implementation. Further, Fullan and Pomfret (1977) in their review of research on curriculum and instruction implementation made a careful distinction between adoption and implementation. The decision to adopt is separate from the process of implementation. Adoption is in many ways a political act; thus, the goals of the political act can be different than the needs felt at the level of the ultimate user who has to effect the implementation. In fact, the urgency felt to secure adoption of an innovation can work against successful implementation. In the words of Fullan and Pomfret (1977):

> Stated in another way, the emphasis is on obtaining adoption, with relatively few resources used for or even allocated to planning for implementation. This probably has the following negative impact on implementation. First, the process of obtaining or determining acceptance by users is bypassed either because of the lack of time, or because rejection or delay cannot be risked. Second, the urgency of getting programs into the field means that inadequate time is spent on specifying the operational implementation characteristics of the innovation. (p. 387)

There are some who advocate a stagewise process of implementation (Lasden, 1982; Mayo, 1975; Ofiesh & Meierhenry, 1964), whereas others recommend installation of an entire system at once (Misselt & Call-Himwick, 1978; Seidel et al., 1978). VanMatre, Pennypacker, and Bortner's (1979) analysis of the implementation of a computer-based training system for the Marine Corps recommended a completed systems design before any implementation, (i.e., a phased implementation, not a phased design). The need for totally debugging a system before implementation has been echoed by others (Kimberlin, 1976; Seidel et al., 1978).

The literature, then, indirectly supports the importance of innovations' being tailored and adapted to specific user needs during the implementation process. Factors related to the user group's ability to take a flexible implementation approach are the inclusion of users in decision making, users' general innovativeness, resource support, and use of a staged implementation approach.

Effective Scheduling of Limited Equipment

McCombs, Back, and West (1984) defined effective scheduling of limited equipment as the deliberate efforts on the part of management and instructor personnel to implement creative and flexible solutions to the scheduling of students for use of

limited equipment items in a self-paced course. This factor was found to be critical in the Air Force technical training context where a large percentage of the courses are performance- and equipment-oriented. One of the benefits of self-pacing is that students can be staggered throughout various knowledge and performance portions of the course, such that the demand for limited equipment items is reduced. This benefit is not always realized, however, if personnel responsible for the implementation and management of the self-paced course have not creatively planned scheduling procedures that are maximally flexible and that avoid student bottlenecks at critical points in the training sequence. These procedures can include creating flexible course hierarchies that provide alternative training activities to which students can be assigned when the limited equipment is in use.

This factor was not specifically identified in the literature reviewed. It is highly related to the previous factor (i.e., flexible implementation approach) and, therefore, does receive some indirect support from the literature discussed in the last section. The common ingredient in these two factors is the attitude and creative approaches of instructor and management personnel in tailoring the self-paced method to meet their unique course requirements.

Staff Involvement/Participatory Management

This factor was defined by McCombs, Back, and West (1984) as deliberate attempts by course management to involve supervisory and instructor staff in decisions regarding the design and implementation of self-pacing. That is, management personnel recognize the attitudinal and motivational benefits of involving their staff and in taking a participatory management approach to the design and implementation of self-pacing.

Rogers and Shoemaker (1971) and Yin (1978) have emphasized the importance of organizational as well as interpersonal dynamics in the innovation process. Organizational considerations include decision-making procedures. Other areas cited as important for user acceptance of an innovation are: (a) subjective factors, (b) utility, (c) participatory decision making and ongoing communications channels, (d) role requirements, and (e) adequate information to understand the new procedures.

In an experimentally controlled study of innovation in drug abuse programs, Stevens and Tornatzky (1980) demonstrated the importance of participative involvement in decision making. They indicated that the number of staff may not be as important as the role of staff who are involved (i.e., inclusion of line as well as administrative staff).

Tornatzky et al. (1980) and Stevens and Tornatzky (1980) reported that involvement of lower-level staff in innovation decisions tended to increase the likelihood of the organization opting for change, and that involving more persons in the implementation process could increase the likelihood of innovation implementation. The former paper is an unpublished manuscript prepared for the National Science Foundation and contains a conceptual, empirical and policy review of innovation process research. The later is a journal article reporting on a factorial experiment with a sample of 37 drug abuse programs.

Fairweather et al. (1974) experimentally compared consultation intervention approaches that differed as to the degree of interpersonal contact based on a national sample of mental hospitals. They found that the more interactive modes of intervention were related to more long-term change and innovation adoption. Stevens and Tornatzky (1980) stressed the importance of face-to-face interaction between recipient and change agent but noted that in their experimentally controlled study, telephone consultations were only slightly less effective than on-site consultations.

The book by Fairweather et al. (1974) on change in mental health organizations and a review by Tornatzky et al. (1980) reported that implementation of a mental health innovation was correlated statistically, and in terms of experimental results, with participative decision making in organizations, and with intervention/consultation techniques which emphasized face-to-face interaction. On the other hand, in an education setting, Charters and Pellegrin's (1973) report on case studies noted that the more participation there is in an implementation process, the greater the likelihood that the innovation will be modified, which may have either positive or negative consequences. In the case of self-paced instruction, however, modification of strict procedures and tailoring to training needs and requirements was found by McCombs, Back, and West (1984) to be positively related to the success of this instructional method.

The power structure in the military is, by necessity, hierarchical. Nevertheless, individual branch chiefs are able to employ a participatory management approach if they so choose. The participatory management approach has been advocated by:

1. Allen (1977) in a review of research on the role of person-to-person communication networks in the transfer of industrial technology;

2. Charters and Pellegrin (1973) in a report on case studies in four public shools;

3. Fairweather et al. (1974) in a book on creating changes in mental health organizations;

4. Freda (1980) in a description of a model of training technology transfer prepared for the Army;

5. Freda and Shields (1980) in an investigation of the adoption process in training technology transfer conducted for the Army;

6. Fullan and Pomfret (1977) in an in-depth examination of 15 case studies measuring implementation in preschool, elementary and secondary education;

7. King (1975) in a review of the literature prepared for the Air Force;

8. Lippey (1975) in a theoretical paper in the Journal of Computer-Based Instruction;

9. Plato (1981) in a review of civilian literature conducted for the Navy;

10. Seidel et al. (1978) in an evaluation of the Computerized Training System of the Army Training and Doctrine Command;

11. Stevens and Tornatzky (1980) in a factorial experiment with a sample of 37 drug abuse programs; and

12. Wolcott (1981) in a theoretical article prepared for Educational Technology.

Seidel and Wagner (1981), in a theoretical chapter commenting on Army efforts with computer-based instruction, made the point that it is important to choose the appropriate organizational structure for a particular project. For example, if a large, complex, lengthy project is being implemented, a pryamid structure or project organizational structure is most appropriate. If an existing system is being implemented, a departmental or functional structure is most appropriate. Based on information derived on previous technical reports concerning the Army's Computerized Training System, Seidel et al. (1978) recommended that there be an unambiguous, single chain of management/authority vested in an integrated component of the targeted school and that this approach be combined with some participatory management. In an article in Computer Decisions, Lasden (1982) cautioned that when resistance reaches a point of illogical and hysterical resistance, and the change is necessary for survival or progress of the organization, some chief executive officer may have to coerce the organizational members into cooperation.

Adequate Staff/Instructor Training and Well-Defined Instructor Roles

McCombs, Back, and West (1984) defined these factors as the deliberate attempts by course management (a) to provide orientation and training in self-paced procedures to all levels of staff and (b) to define and communicate instructor role requirements in a self-paced course. In the case of instructors, this also includes the formal provision of training in the roles required of them in a self-paced course.

Numerous authors have recommended that multilevel staff training and orientation should be provided for either self-paced or computer-assisted instruction. These include:

1. Cohen (1981) in a theoretical paper delivered at a meeting of the American Educational Research Association;

2. Freda (1980) in a description of a systems model of training technology transfer prepared for the Army;

3. Freda and Shields (1980) in a report on the adoption process in training technology transfer prepared for the Army;

4. Magarrell (1976) in a review article in the Chronicle of Higher Education;

5. Mayo (1975) in a theoretical paper presented at a conference and subsequently published in the Journal of Computer-Based Instruction;

6. McCombs and Dobrovolny (1980) in their development of a theoretical role model for the instructor in a computer-managed environment;

7. Plato (1981) in a review of civilian literature prepared for the Navy;

8. Seidel and Wagner (1981) in a theoretical chapter in which reference is made to Army efforts in computer-based instruction;

9. Sprecher and Chambers (1980) in a survey of 519 accredited, 4-year, public institutions of higher learning;

10. Wolcott (1981) in a theoretical article appearing in Educational Technology; and

11. Wollitzer (1977) in a review of the literature in the Journal of Computer-Based Instruction.

Discussions on instructor needs range from the need for more training to the need to be involved in decision making as a means of reducing stress and burnout. Boredom, role overload, role ambiguity and lack of control over decision making may result in burnout and have a negative impact on the success of self-pacing. The problem of burnout will be considered first in this review and will then be followed by suggestions for reducing this problem, including training.

Cherniss (1980), in a theoretical book on job stress in the human services, described burnout as a process consisting of three stages. The first stage involves an imbalance between resources and demand (i.e., stress). The second stage is the immediate, short-term emotional response to this imbalance, characterized by feelings of anxiety, tension, fatigue and exhaustion (i.e., strain). The third stage consists of a number of changes in attitude and behavior (i.e., defensive coping). "Burnout thus refers to a transactional process consisting of job stress, worker strain, and psychological accommodation. It is a process in which a previously committed professional disengages from work in response to stress and strain experienced on the job" (Cherniss, 1980, p. 17). Burnout is not the same as temporary fatigue or strain, although such feelings may be an early sign of burnout.

Stress is defined as either (a) a situation in which environmental demands exceed the resources of the person or (b) one in which the person's resources greatly exceed demand. This latter situation is known as boredom or underload. "Lack of challenge, underutilization of abilities and skills, and a paucity of intellectual stimulation are potentially important causes of burnout" (Cherniss, 1980, p. 45). This is the very type of feeling described by military instructors who believe their skills are not adequately used in self-paced instruction (McCombs, Back, & West, 1984).

A second major source of burnout is organizational design according to Paine (1982) and Pines (1982) who reviewed research on job stress. The components of organizational design are role structure, power structure, and normative structure (Cherniss, 1980). Role structure is the way tasks and duties are allocated among specified roles in a setting. Some role structures tend to create stress and strain while others provide stimulation and individual involvement and satisfaction. Examples of negative role structures are role overload; role conflict, in which a role occupant is sent two messages whereby it is impossible to comply with one without disobeying the other; and role ambiguity, in which the role player lacks the information necessary for adequate performance of the role. Power structure relates to the manner in which decisions are made. Research suggests that hierarchical decision making increases job stress and burnout. Normative structure refers to the goals, norms and ideologies of an organization. Programs in which the general goals are broken down into more specific operational objectives are associated with lower levels of job stress.

In fact, the literature suggests that successful implementation of self-paced instruction is associated with reducing instructor overload through the provision of support staff and/or flexible scheduling.

This point is supported by:

1. Caffarella et al. (1980) in an empirical study of self-paced instruction conducted for the Army;

2. Hartman and Garnett (1981) in a theoretical paper prepared for a civilian conference;

3. Kimberlin (1976) in a status report on the Army's Computerized Training Systems Project;

4. King (1975) in a review of the literature on computerized instruction conducted for the Air Force;

5. Lindvall and Bolvin (1967) in a theoretical chapter in a book on programmed instruction;

6. Magarrell (1976) in a review article in the Chronicle of Higher Education;

7. Montemerlo and Harris (1978) in a theoretical paper prepared for the Air Force Academy;

8. Van Matre et al. (1979) in an analysis of a computer-based education system conducted for the Marines;

9. Wang (1980) in a review of the literature prepared for a civilian audience; and

10. Wilkie (1979) in an empirical study conducted in high schools.

Role ambiguity for the self-paced instructor can be addressed via role training specifically tailored to that mode of instruction. According to the Training Developments Institute's (1980) assessment of the effectiveness of self-paced courses in the Army, training effectiveness is impaired when instructors and training developers have not been trained in the skills required to manage and develop self-paced instruction. Fullan and Pomfret (1977) examined in detail 15 civilian case studies of instruction and implementation and concluded that instructor role training is crucial to success:

> The main problem appears to be that curriculum change usually necessitates certain organizational changes, particularly changes in the roles and role relationships of those organizational members most directly involved in putting the innovation into practice. That is, role occupants are required to alter their usual ways of thinking about themselves and one another and their characteristic ways of behaving towards one another within the organization. Often the organizational (role relationship) change aspects of curriculum projects are left implicit in the plans. Less often, an effort is made to address them directly. In either case, problems inevitably arise during the attempt to put such changes into practice. (p. 337)

Well-defined instructor roles and adequate instructor role training also have been cited as crucial to the successful implementation of self-paced instruction by:

1. Kimberlin (1976) in a status report on the Army's Computerized Training Systems Project;

2. King (1975) in a review of the literature prepared for the Air Force;

3. Lindvall and Bolvin (1967) in a theoretical chapter in a book on programmed instruction;

4. McCombs and her colleagues (McCombs & Dobrovolny, 1980; McCombs, Dobrovolny & Lockhart, 1983) in both their definitions of theoretically based instructor roles in a self-paced, computer-managed instructional environment and their empirical evaluation of the effects of training in these roles in Navy and Air Force CMI courses;

5. Misselt and Call-Himwick (1978) in an analysis of the Sheppard AFB Computer-Based Education Project which was based on secondary sources of information; and

6. Shuell (1978) in a theoretical paper that was nonmilitary in focus.

The evaluation of the CMI Instructor Role Training Package by McCombs, Dobrovolny, and Lockhart (1983) indicated that the package met the goal of providing relevant and needed training in both the Navy and Air Force CMI settings. The 12-module training package was incorporated into a 20-hour training program wherein instructors were taught skills for performing a total of seven theoretically based roles within the role

categories of Learning Manager and Learning Facilitator. The seven roles are Planner (of classroom operations), Implementor/Monitor, Evaluator, Diagnostician, Remediator, Counselor, Modeler. Instructor training in these roles contributed to more positive student attitudes toward CMI and toward their CMI instructors, and generally contributed to lower student elimination rates. Instructors participating in the training indicated that they not only found the training to be relevant and helpful in performing their CMI roles, but found that it motivated them to try new techniques in their learning centers and had given them skills for handling problem situations and improving their relationships with students. Role training of this type can, therefore, be highly related to instructor satisfaction and motivation to perform well in a self-paced environment.

High Instructor Dedication/Motivation

This factor was defined by McCombs, Back, and West (1984) as high levels of instructor understanding, dedication, and motivation to perform well in a self-paced method of instruction. As such, it is conceptualized as an outcome of the previously defined combination of management factors shown in Figure 1. Much of the literature already reviewed, therefore, speaks indirectly to the issue of instructor dedication and motivation.

Plato (1981) stated that change should be well planned and well executed to enhance user acceptance. Consideration should be given to the social environment and attitudes/needs of staff. Because of their critical role, middle managers should have their attitudes measured before projects are started and upper management should make every attempt to foster positive attitudes in middle management from the start. This last strategy touches upon the use of the change agent in influencing attitude.

Suggestions for facilitating the adoption of innovations fall into two major categories: (a) those stressing the importance of involving users at all levels of the implementation process and (b) those emphasizing the need to designate a person (i.e., change agent) to effect a positive attitude among the potential users.

According to Seidel et al. (1978), involvement of the users begins with ensuring that there is universal agreement on project purposes and requires frequent meetings to monitor the atmosphere of expectation and understanding. Lippey (1975) recommended (a) including user opinions and judgments, (b) being careful not to intimidate users, and (c) avoiding competing with the administration for scarce resources. Ofiesh and Meierhenry (1964) suggested recognizing the instructor as the focal point. Misselt and Call-Himwick (1978) stressed the value of involving instructors in curriculum development and making use of existing communication channels. Freda and Shields (1980) recognized that acceptance by the user is critical and that efforts should be directed toward key personnel internal to the innovation to motivate them to integrate, adapt, and/or modify the program to fit internal needs.

Summary

This section has focused on literature related to management factors which were found by McCombs, Back, and West (1984) to be critical to the success of self-pacing.

With the exception of "effective scheduling of limited equipment," which was not directly addressed in the literature reviewed, all factors found some support in terms of their importance. A number of the references cited also stressed the point that many factors operate in combination to produce a successful implementation of innovative technologies in general and self-pacing in particular.

For example, Wolcott's (1981) conceptual analysis of change in education cautioned against common pitfalls in the innovation process: not allowing the user to define needs that technology could be matched to solve; not providing the user with enough information to understand the technology; and forcing the user to use the innovation rather than making it voluntary. Wolcott stressed the need to foster attitudes that change is "for" the users, not something that is being done "to" them.

In a review of literature on faculty perspectives on computer-based education, Wollitzer (1977) cited other factors which may limit acceptance of a new technology. These include the need to learn a new discipline (and lack of motivation to do so), laziness, role overload, the need to do it one's "own" way, and lack of incentives. This last point concerning incentives has received very little attention from theoreticians or researchers.

Davidson and Schmitt's (1979) proposal to the National Science Foundation also cited reasons for nonadoption: lack of clarity about the technology's use, lack of skills necessary to operate the technology correctly, value differences between the technology and the user, resistance to change (which is sometimes disguised as "local adaptation"), organizational structures which prevent its use, and lack of the materials necessary for the technology's use.

In a study of the innovation process in public organizations, Rogers et al. (1977) concluded that the professionalism of the user agency staff, as measured by their formal education and membership in professional associations, was not very important in the innovation process. Likewise, general innovativeness of the organization was not related to the degree of adoption. They concluded that organization characteristics are not very helpful in understanding the innovation process but suggested that this could be due to shortcomings in measurement.

Any discussion on the topic of effectiveness of technology transfer should also include an examination of the pro-innovation bias. This is the belief that innovativeness leads to better productivity. Likewise, there is pro-transfer bias which assumes that transfer prevents each entity from having to reinvent the wheel, that everyone benefits from transfer, that transfers are less costly than developing innovations in-house and that more transfer would occur if there were a national clearinghouse and resource center to make information and computer applications available. Kraemer (1976) conducted numerous studies of the transfer of computer applications and neither supported nor refuted the claims about transfer. The decision to transfer may have to be made on a case-by-case basis, and individual cases may or may not be facilitated by outside funding.

In the examination of 15 case studies described previously, Fullan and Pomfret (1977) cited in-service training, resource support, feedback mechanisms to the implementors, and participation in decision making as important to implementation:

> It is important to note that these factors are interactive in the sense that they may be mutually reinforcing over time. The presence of any one without the others would probably limit if not eliminate its effectiveness. (p. 371)

In the past decade, the literature on technology transfer has attained greater recognition and the studies have become more rigorous. Early studies were limited to isolated case studies of cross-cultural transfers (Rogers & Shoemaker, 1971), whereas more recent ones have included large samples (Stevens & Tornatzky, 1980; Tornatzky & Klein, 1982; Yin, 1978) and have made use of theoretical models (Davidson & Schmitt, 1979; Pelz & Munson, 1980).

Recommendations derived from the literature which can be applied to implementation of self-paced instruction include:

- involvement of personnel in the decision to adopt and in the planning and implementation stages
- incorporation of outside expertise and training of in-house personnel where appropriate
- strong management support for the continued application of an innovation that has been adopted
- ongoing two-way communication among personnel and implementors

Recognition of instructor expertise and inclusion of instructors in the decision-making process is considered an important component of the success of any mode of instruction. Also important to successful implementation is (a) reducing instructor overload through the provision of support staff and/or flexible scheduling, (b) role training for instructors, and (c) multilevel staff training and orientation.

INSTRUCTIONAL FACTORS

In addition to the management factors discussed in the previous section, a number of instructional factors were found to be critical to the success of self-pacing in Air Force technical training (McCombs, Back, & West, 1984). This section reviews literature relevant to these instructional factors (see Figure 1).

Method Matched to Knowledge/Performance/Field Requirements

McCombs, Back, and West (1984) defined this factor as the design of a self-paced course and materials such that they are matched to the particular requirements of that course. More generally, this factor refers to attempts to tailor the self-paced method specifically to match unique course needs and requirements.

Tailoring an innovation to the particular circumstances in a school or course has been found to be related to successful adoption of that innovation in civilian applications (Charters & Pellegrin, 1973; Hartman & Garnett, 1981; Kearsley, 1977a; Merrill, Towle, & Merrill, 1975; Shuell, 1978; Wolcott, 1981) as well as the military (Seidel et al., 1978). It should be noted that Kaufman (1982) and Seidel et al. (1978) have stated that if an existing course is satisfactory, then a change in format should not be introduced (thus representing civilian and military experience, respectively).

Several authors have included the step of task analysis in the systems approach as a method for tailoring instruction to unique course needs. Kearsley's (1977a) conceptual framework for instructional design included the need for a task analysis, learner analysis, and means analysis. According to Kearsley, selection of the appropriate instructional means must be determined by the relevant learner and task dimensions. No single authoring technique can be expected to apply to all tasks and learners.

The need to conduct an analysis of the task to be performed was also cited by Branson (1977), in a discussion of military and industrial training. Hartley (1972) elaborated on this point in a discussion of civilian instruction, stating that from the task analyses are determined the optimal teaching sequence, the appropriate teaching strategies, and the appropriate presentation methods. Without such an analysis of task requirements, tailoring of the self-paced method to unique course needs is difficult, if not impossible.

Continual ISD Process

This factor was defined by McCombs, Back, and West (1984) as the dedication of course management personnel to the continual evaluation and revision of its self-paced materials and procedures, based on an application of the ISD process. That is, the importance of continual feedback and evaluation of course performance data, as well as the need to make appropriate revisions based on these data, is recognized.

The need to use ISD procedures in the development of instruction was disucssed in the first section of this paper. The fact that ISD procedures are frequently incomplete,

however, was pointed out in a study by Vineberg and Joyner (1980). They studied ISD methodologies and practices in the Army, Navy, Marine Corps and Air Force utilizing a questionnaire survey of 109 units, agencies and schools where training is developed. In addition, they did an analysis of the primary guidance documents used in the Armed Services for conducting ISD and conducted detailed interviews of training developers at 33 organizations to determine how 57 courses were designed. They found that many of the components of ISD were omitted, particularly those evaluation activities following instructional development, and that the close connection between components which makes the process derivative was not maintained. Vineberg and Joyner (1980) concluded that the potential of ISD to ensure that training meets job requirements was not being realized. The authors recommended that operational commands be given a larger role in identifying job requirements, in establishing training requirements, and in evaluating the performance of training graduates. They also provided specific recommendations for 19 steps of the ISD process.

In a nonempirical paper Roblyer (1981) highlighted four major distinctions between the traditional course authoring and instructional design (i.e., the ISD process):

- instructional design procedures follow a theory-based model;
- prior to actual development, instructional design requires written products which specify in detail the intended outcomes of the courseware and how the materials are to appear;
- instructional design implies a team approach to development, usually including a content area expert, an instructional designer and a programmer; and
- instructional design methods usually include some provision for a formative review and revision phase.

This later stage was cited as particularly important for maximizing instructional effectiveness.

Briggs and Wagner (1981), in a handbook on the design of instruction, described formative evaluation as taking place while the instruction is being formed. This type of evaluation can often reveal many weaknesses in the instruction. While the purpose of formative evaluation is to improve the instruction by comparing goals and objectives to actual outcomes of the instruction and making needed improvements, the purpose of summative evaluation is to determine whether the system met its intended goals and objectives.

> It is sometimes said that the purpose of formative evaluation is to improve the instruction in efficiency and effectiveness, while the purpose of summative evaluation is to prove the value of the system, both in pedagogical and economic terms. (Briggs & Wagner, 1981, p. 208, emphasis original)

Montemerlo and Harris (1978) warned against the danger of ISD becoming a ritualistic rather than a problem-solving process:

> The problem is exacerbated if the ISD team perceives they are more likely to be punished for failure to follow the rules than to be rewarded for doing whatever necessary to solve the problem. The lower the rank/status of the ISDers, the more likely this phenomenon will occur. Straying from the procedure requires the knowledge of alternatives, the confidence to implement them, and the perception that that is what is wanted. To inhibit the ritualization of course design procedures, an organization must make it clear that results, not ritual are desired. (p. 2)

The literature, therefore, supports the importance of following ISD procedures, including a continual evaluation of how well the instructional system and materials are meeting training goals and objectives.

Quality Instructional Materials

McCombs, Back, and West (1984) defined this factor as the presence of instructional materials of adequate quality, matched to student needs, and in an appropriate format for specific learning requirements. As such, this factor is highly related to the preceding factors, continual ISD process, method matched to knowledge/performance/field requirements, as well as to the outcome of all the instructional factors listed in Figure 1 (i.e., method matched to student needs).

In a paper prepared for the Air Force Academy, Montemerlo and Harris (1978) suggested that no institution can effectively analyze its own instructional needs because embarrassing information might arise. They recommend that the design team leader be an outsider and independent of pressures that could be brought to bear to cover up organizational shortcomings.

On the other hand, the literature, both civilian and military, generally supports the use of in-house personnel for curriculum development, provided there is adequate training in this area and release time for instructors (Freda & Shields, 1980; Luskin et al., 1972; Misselt & Call-Himwick, 1978; Seidel & Wagner, 1981; Sprecher & Chambers, 1980). If curriculum materials are prepared by an outside contractor, contract personnel should work on-site as much as possible and in close cooperation with training personnel.

Overriding the concern with in-house versus outside materials development is the concern for quality instructional materials. The prevailing point of view is that curriculum development is best accomplished by a team of persons with expertise in the content area, in instructional design, and in computer programming (Misselt & Call-Himwick, 1978; Roblyer, 1981).

Hartman and Garnett (1981) recommended a structured approach to the development of CAI, in a discussion of civilian education:

> Each task or content area should be subjected to a task analysis to identify the independent and dependent sequences which lead to performance of the task or acquisition of the content. Another outcome of the analysis is the identification of prerequisite knowledge and skills which are essential to performance of the task or mastering the content. (p. 120)

Within this approach, Hartman and Garnett (1981) recommended that the task analysis begin with an identification of learning hierarchies as outlined by Gagne.

According to Montemerlo and Harris (1978), who prepared a theoretical paper on the pitfalls of ISD, successful application of ISD requires an interdisciplinary team of subject-matter experts and skilled instructional technologists. In an interview for Educational Technology focusing on computer technology in general education, Gagne (1982) advocated a team approach to curriculum development.

In a report prepared for the Army, Hungerland (1979) utilized a quasi-experimental design to assess two courses in which the development of the course structure and course materials assumed a systems approach and employed instructional principles derived from established cognitive and behavioral learning theories. Experimental and control groups were employed, using a posttest-only design, with nonrandom groups and unequal n. Two experimental courses were run concurrently with conventional courses. Among their conclusions were the following:

- individualized instruction in the courses studied is feasible to implement and operate; and
- within individualized instruction, trainees can achieve higher levels of skill competence (100% criterion) in the same or less time than it takes trainees to achieve a lower level of skill competence (70% criterion) using conventional instructional methods.

Thus, the potential of self-pacing is maximized when systematic instructional development procedures are used to produce quality instructional materials.

Incorporation of Team and Group Activities

This factor was defined by McCombs, Back, and West (1984) as the provision within a self-paced format for periodic team and group activities to supplement individual activities. The presence of this factor within a self-paced course represents a form of tailoring the instructional method to unique student and training task needs.

As an example of the need to integrate group and individualized activities, Briggs and Wagner (1981) cautioned against the exclusive use of CAI in a class of over 30 students. In a previous theoretical discussion on instructional design, Briggs (1977) recommended the use of group meetings/discussions in courses that are heavily materials-dependent. These group activities serve several purposes:

- allowing students to compare notes on progress and to discuss problems;
- allowing the instructor the opportunity to illustrate principles and discuss real life experiences;
- providing students with support from other students and the instructor;

- giving students encouragement by hearing the instructor discuss problems other students have had and how they have solved them;
- providing students with feedback; and
- stimulating students' attention and motivation.

In a study of 19 Navy schools, Hall and Freda (1982) concluded that when course content was classified into generic training tasks, individualized instruction was more effective than conventional group instruction in courses that taught procedure tasks. Conventional group instruction was more effective than individualized instruction in courses that taught rule or principle tasks.

> No one method of instruction was found to be universally more effective in training all of the different types of tasks to different ability level students. The evidence of this study suggests that a combination of methods used within a given course for conveying different instructional contents would likely be more effective than use of a single method for an entire course. (Hall & Freda, 1982, p. 2)

Since most military technical training courses consist of a combination of knowledge (rule or procedure) and performance (procedure) tasks, these findings imply that a combination of group and individual activities is appropriate for maximizing training effectiveness.

Opportunities for Student/Instructor Interaction

McCombs, Back, and West (1984) defined this factor as the deliberate attempts within a self-paced course to set up specific opportunities for student/instructor interactions; these could include small group discussions as well as defined instructor roles and procedures that include student/instructor interactions. As such, this factor is closely related to the preceding factor, incorporation of team and group activities.

The need to allow for sufficient interaction between students and instructors has been cited by several authors. Misselt and Call-Himwick (1978) conducted a study of the Sheppard AFB Computer-Based Education project through the use of secondary sources (e.g., copies of correspondence and documents by Sheppard staff, previous site visit notes, and reports by project staff and AFHRL researchers). They found that there was insufficient opportunity for students to interact with instructors.

King's (1975) review of the educational, psychological, technological, and computer literature on computer-based instruction concluded that it is necessary to ensure that instructors are present and accessible for answering questions. Observations indicated that students initiate more questions in CAI classrooms than in conventional classrooms; however, the questions tended to be direction-oriented (How do I do this?) rather than subject-matter-oriented. King (1975) stated that self-paced instruction would be enhanced if students had access to indices of individual performance relative to peer performance. In a theoretical paper prepared for an education conference, Shuell (1978) stressed the importance of feedback to students but noted that this can be accomplished in both group and individualized instruction.

Adequate Mix of Media

In McCombs, Back, and West (1984), adequate mix of media was defined as the provision in course design for the implementation of instructional materials in a variety of formats and media, including the use of CAI where appropriate. This definition implies that heavy reliance on a single instructional medium (e.g., programmed text) is detrimental to the success of self-pacing.

A theme that recurs in the literature is the need to match the content area and type of skills required to the appropriate mode of instruction (Blumenfeld, Newman, Johnson, & Taylor, 1979; Gagne, Reiser, & Larsen, 1981; Kearsley, 1977a; Shuell, 1978). In a theoretical paper prepared primarily for a civilian audience, Dunn and Dunn (1974) stressed that

> before students can be grouped for instruction by matching how they learn with how the program will require them to learn, it is necessary to (1) identify and understand learning style, (2) identify the learning style requirements of selected programs, and (3) compare the student's learning style profile with the demands of the program. (p. 275)

A research study conducted for the Army Training Support Center of the Training and Doctrine Command resulted in a report describing a new media selection model aimed at improving procedures for media selection in U.S. Army training (Gagne, Reiser, & Larsen, 1981). Derivation of the model focused upon principles of human learning which affect decisions about media, in particular the nature of learning outcomes and the events of instruction. One component of the model was consideration of learner characteristics, including amount of experience as a learner and ability to read.

In the review paper cited earlier Shuell (1978) reviewed three general ways of characterizing matches between learner aptitudes and instructional methods. These were capitalization, compensation, and remediation:

> Capitalization is a match that builds on the strengths of the learner .... A match made on this basis would capitalize somehow on the strengths or preferences of the learner. Compensation refers to a match in which the instructional treatment does something for the learner that he cannot do for himself. For example, let's take the hypothetical case in which a teacher puts detailed notes on the chalkboard or distributes a mimeographed lecture outline for students who are low in their memory ability. Finally, remediation refers to those situations in which the learner is provided with knowledge or skills that he [sic] is lacking but capable of learning and are prerequisites for the instructional unit being presented to the class. (pp. 20-21)

Shuell (1978) pointed out, however, that it is likely that attempts to match on a unitary factor may prove to be impossible or undesirable:

> The objective that the learner is trying to achieve must be considered when making an appropriate match, and there may be times when the

> desired objective is antagonistic to the learner's preferred or optimal style of learning .... Since it is usually desirable to match on several different factors simultaneously, careful consideration of the various factors and the interactions among them is required. Multiple outcomes, as well as multiple sources of individual differences, must also be considered. (p. 21)

According to a theoretical review of civilian literature, with some reference to the Time Shared, Interactive, Computer-Controlled, Information Television (TICCIT), a system marketed by Hazeltine Corporation, Kearsley (1977b) concluded that:

> There is a wide gulf between the level of individualization described by educators and promised by some CAI adherents and what actually now exists. Moreover, there has been insufficient theoretical consideration of how parameters of individual differences are to be related to instructional parameters. (p. 10)

It should be noted that Kearsley was writing in 1977, and technological advances since then have resulted in better products. In support of this point, a meta-analysis of studies on the effectiveness of programmed instruction in higher education indicated that the more recent studies have reported results more favorable to programmed instruction than did the earlier studies, which suggests that the technology and curricula have steadily improved (Kulik, Cohen, & Ebeling, 1979).

Method Matched to Student Needs (Ability, Motivation, Maturity)

This factor was conceptualized by McCombs, Back, and West (1984) as the outcome of the combination of instructional factors defined in this section (see Figure 1). It was defined as the use of self-paced, group or multimedia techniques that are matched to student entry characteristics (ability, motivation, maturity) and preferences for particular learning modes (type of instructional media).

A frequently cited cause for the lack of success of self-paced instruction is that inadequate provision is made for student needs. The literature abounds with references cautioning that the reading levels and cognitive abilities of students must be considered when forming either a self-paced or CAI plan of instruction (Blumenfeld et al., 1979; Caffarella et al., 1980; Federico & Landis, 1979; Gagne et al., 1981; Hall & Freda, 1982; Hartman & Garnett, 1981; Kearsley, 1977a; Kimberlin, 1976; Montemerlo & Harris, 1978; O'Day et al., 1971; Shuell, 1978; Zajkowski et al., 1979). While most of the above authors view high ability as a positive factor in the success of self-paced instruction, O'Day et al. (1971) cautioned that high ability students learn better with a plain text because self-paced materials may be inefficient. In their empirical study of Navy recruits and civilian college students in nine experimental instructional conditions, they found that brighter students took less time on a program and made fewer errors and that the Navy recruits were more highly motivated than were college students. The latter finding may have been the result of the Navy students' recent graduation from recruit training and the influence of military discipline.

A review article in the Chronicle of Higher Education stated that there was "considerable evidence that self-paced learning is particularly beneficial to students who

perform poorly in traditional courses" and that "studies of computer-based methods also have shown significantly higher achievement than students taught by conventional methods" (Magarrell, 1976, p. 6).

Kulik, Cohen and Ebeling (1979), in a meta-analysis on studies examining the effectiveness of programmed instruction in higher education, reported that the effects of programmed instruction were equally clear on high and low aptitude students. Kulik, Kulik, and Cohen (1980) found in their meta-analysis of CBI at the college level that the boost that computer-based teaching gave to student achievement was about equal for high and low ability students, as well as average students.

In a subsequent meta-analysis of studies on computer-based teaching at the secondary school level, Kulik, Bangert, and Williams (1983) concluded that

> the effects of computer-based tracking seemed especially clear in studies of disadvantaged and low aptitude students, for example, whereas effects appeared to be much smaller in studies of talented students. (pp. 25-26)

The authors suggested that:

> at the lower levels of instruction, learners need the stimulation and guidance provided by a highly reactive teaching medium. At the upper levels of instruction, a highly reactive instructional medium may not only be unnecessary but may even get in the way. College learners apparently profit from working by themselves on problems before receiving individual evaluations and prescriptions for further work. (p. 21)

Misselt and Call-Himwick (1978) indicated that if students are highly motivated and grade oriented, computer-based education may not be effective. In that study the Sheppard AFB Computer Based Education project was studied through the use of secondary sources (e.g., copies of correspondence and documents by Sheppard staff, previous site visit notes, and reports by project staff and AFHRL reseachers).

Hall and Freda (1982) conducted a study of individualized and conventional instruction in Navy technical training in 19 Navy "A" Schools including more than 5,000 students. The study focused on relationships among method of instruction, ability level and type of training task, training time, training costs, end-of-course grades, and fleet supervisor ratings. Findings included the following:

- individualized instruction and conventional instruction were equally effective in preparing sailors for operational fleet jobs;
- within the individualized instruction category, self-paced and computer-managed instruction were found to be equally effective training methods;
- individualized instruction benefited higher ability students more than it did lower ability students;

- conventional instruction did not benefit one ability level of students over another; and

- whether conventional instruction or individualized instruction was more effective in teaching training tasks depended on course content.

Several authors have suggested that the learning and/or cognitive styles of students should receive consideration. Federico and Landis (1979) conducted an empirical study of students in the Navy's Basic Electricity and Electronics Schools. They found that cognitive characteristics can be used to predict student performance and that different cognitive characteristics contribute differentially to student performance at distinct modules or stages of learning.

Other authors have pointed to student maturity as an ingredient for the success of self-paced instruction. In fact, Magarrell (1976), McCombs (1982, 1983), Milner (1979) and Wang (1980) have recommended teaching students to exercise self-discipline, self-motivation, and self-management skills.

In a discussion of characteristics of successful students in a self-paced, individualized, or computer-managed environment, McCombs (1982) stated that students should "(a) be attentive and motivated; (b) make learning meaningful by the appropriate use of learning strategies and skills; (c) practice personal responsibility skills required for self-initiated, self-directed, and self-paced learning; (d) interact effectively with both their peers and their instructors; and (e) set appropriate course and life goals" (p. 11). That many students have difficulty exercising these skills and responsibilities was substantiated in McCombs's research with students in self-paced military technical training courses. She has developed and evaluated skill training packages with military students in the areas of time management/orientation to CMI (Judd, McCombs, & Dobrovolny, 1979); study skills (McCombs, Dobrovolny, & Judd, 1979); and self-management/self-motivation (McCombs, 1982, 1983).

Milner (1979) attributed student attrition to implicit time limits in the course and inadequate skills in self-management. In a paper on determining the feasibility of computer-based instruction, which was prepared for the Workforce Effectiveness and Development Group of the U.S. Office of Personnel Management, he suggested that students may need some form of guidance with respect to self-pacing strategies in individualized learning. This need was also recognized by Judd et al. (1979) and Pennypacker, Van Matre, Hartman, Brett, and Ward (1980). The latter authors independently developed and evaluated computer-based time management procedures for CMI students.

Magarrell (1976) reported that faculty members and administrators at universities complained about student procrastination in self-paced instruction (i.e., that the students did not know how to pace themselves). At one university Magarrell (1976) found that by gradually extending and relaxing deadlines, students could be taught to exercise self-discipline. Wang's (1980) review of the literature on elementary age children recommended teaching students self-management skills such as how to search for useful information and how to order and organize this information for learning and retention.

Caffarella et al. (1980) suggested using alternative procedures for low and high motivation students. This study, sponsored by TRADOC, investigated 25 self-paced courses at seven locations. (No information is available on the type of data collection procedures used.) The authors recommended consideration of six dimensions in instructional design, including the instructional setting, instructional tasks, course management, instructor characteristics, and student characteristics.

The concept of adaptive instruction has been described by Wang (1980) as the use of alternative instructional strategies and resources to meet the learning needs of individual students. Wang's review of the literature focusing on elementary age children concluded that there had been a substantial and growing interest in developing educational programs and instructional technologies that adapt school learning to the differing abilities, experiences, interests, and socioeconomic backgrounds of children.

Hickey (1975) attempted to point out relevance for learning in the military setting in a review of primarily civilian literature prepared for the Joint Services Advanced Training Technology Program. Included in his recommendations for instructional design were provisions for differing abilities, aptitudes, personality types, information processing styles, cognitive styles and perceptual abilities.

It has been suggested by some that allowing students to choose from alternative modes of instruction will improve their performance. In a study of the effect of student choice in a Basic Electricity/Electronics course in the Navy, McCann, Lahey, and Hurlock (1973) compared two types of adaptive instructional strategies: (a) the student selected his or her own training and (b) the course program controlled training for the student based on his or her pretest results. In addition, the influence of having the student read a narrative overview of training content before CAI instruction on each lesson was also examined. The authors reported the following results:

> No significant differences were found between the four experimental conditions in test performance or training time measures. Questionnaire data indicated that students who selected their own training maintained a significantly more favorable attitude toward CAI. In addition, students who had a pre-training narrative available to them felt that it was a valuable aid. (McCann et al., 1973, p. iii)

In contrast, the best indicators of success in CAI training were scores on previous school examinations and prior time spent in the school's individualized training curriculum. Performance was not significantly related to General Classification Test scores or to two aptitude measures (McCann et al., 1973).

A study by Caffarella et al. (1980) of self-paced instruction in 25 military courses, which was conducted for TRADOC, concluded that an assessment should be made of the amount of orientation needed by students prior to beginning a course. Milner's (1979) theoretical paper indicated that students may need help in adjusting to self-paced learning, particularly if there are implicit time limitations. King (1975) systematically investigated the educational, psychological, technological, and computer literature on computer-based instruction and prepared a report for the Air Force Human Resources Laboratory on the impact of computer-based instruction on students and instructors. She stated that self-pacing would be enhanced if students had experience with self-pacing and/or orientation and initial contact prior to initiation of a technical course.

Zajkowski et al. (1975) conducted a study (a) to establish the status of individualized instruction in the Navy, (b) to identify the factors influencing its effectiveness, (c) to identify present or potential problem areas, and (d) to recommend strategies for improving individualized instruction in Navy technical training. The study consisted of three components. First, all relevant Navy instructions and directives were reviewed and an assessment was made of their impact on the implementation and management of individualized instruction in the Navy. Second, key summary articles pertaining to the effectiveness/efficiency of individualized instruction were reviewed in an attempt to establish a consensus concerning the utility of this instructional strategy. Third, visits were made to key sites in the Navy and other military services where information pursuant to the establishment of a comparative data base on individualized instruction was obtained. The authors recommended providing preparatory materials on the use of computers in instruction of students and instructors and highlighted the need for educators to address the unrealistically high expectations that students may have for CAI.

Plato (1981) reviewed the literature pertaining to attitudes toward computer-based systems that were not necessarily instructional and were primarily civilian in focus. In the case of computer-assisted instruction, she recommended that education and orientation to the computer should be given to all levels and age groups.

Summary

General support was found in the literature for the importance of all of the instructional factors listed in the McCombs, Back, and West (1984) synthesis of factors critical to the success of self-pacing in Air Force technical training. None of the literature reviewed spoke directly to the issue of particular combinations of instructional factors that result in the materials being matched to student needs. There appears to be general agreement, however, that if instructional designers follow a systems approach to the design and implementation of instruction--including task and performance analysis, incorporation of alternative media and individual and group activities, provision for sufficient student/instructor interactions, continual evaluation and revision, and the inclusion of specialized student skill training in self-management and self-motivation--the result will be materials matched to student needs.

While there is agreement in the literature on the need to consider student factors in designing an instructional program, there are conflicting findings and opinions as to how student characteristics are related to differing modes of instruction. The most definitive conclusions in this area have been drawn from the meta-analyses conducted by Kulik, Bangert, and Williams (1979, 1980, 1983). Overall, the findings seem to indicate that CAI and programmed instruction may be appropriate for lower levels of instruction but that college learners profit from working by themselves on problems before receiving individual evaluations and prescriptions for further work.

This conclusion is apparently in agreement with the study by Hall and Freda (1982) of 19 Navy Schools. In that study it was concluded that when course content was classified into generic training tasks, individualized instruction was more effective than conventional instruction in courses that taught procedure tasks. Conventional instruction was more effective than individualized instruction in courses that taught rule or principle tasks.

Despite the call for matching the learner to the mode of instruction and the task to be learned, which has been echoed by many theoreticians cited above, the feasibility of implementing these matches may remain elusive as Kearsley (1977b) and Shuell (1978) indicated. The trend toward increasingly favorable findings for programmed instruction in recent years (Kulik, Cohen, & Ebeling, 1979) may suggest a more promising future, however.

COST CONSIDERATIONS

Cost and Cost Effectiveness

Any decision on adopting an innovation must inevitably focus on cost and cost effectiveness. The interest expressed by the Department of Defense and the military services in the various forms of self-paced instruction has been largely due to the perception that this form of instruction would improve the cost effectiveness of training. The goal of cost effectiveness is also expressed in the Instructional System Development Manual, which states that the intent of applying ISD is to develop quality training at the least cost.

Research studies on the cost effectiveness of self-paced instruction and CAI have been inconclusive. Kulik, Cohen, and Ebeling (1979) applied meta-analytic methodology to 57 studies of the effectiveness of programmed instruction at the college level and found:

> Students in programmed classes averaged about one-quarter standard-deviation-unit higher on examinations than did students in conventional classes. . . . Programmed instruction also tended to reduce the amount of study time required from students, but it had little effect on student ratings of instruction or on course completion rates. (p. 1)

In another meta-analysis, Kulik et al. (1980) studied the effectiveness of computer-based college teaching and found that when compared to conventional instruction, CBI raised examination scores by .25 standard deviations and took only two-thirds the time of conventional instruction. In a review of the literature, Sprecher and Chambers (1980) found that CAI reduces student mean time for course completion from one-half to one-third that required by more conventional approaches. Jamison, Suppes, and Wells (1974) conducted an extensive review of the literature which was published in a civilian journal. They concluded that at the secondary school and college levels, programmed instruction and computer-assisted instruction are less time consuming than conventional instruction.

Claims have been made that technology can decrease educational costs, primarily by replacing teachers and other staff, and increase educational productivity. In a review of the civilian literature, Shavelson and Winkler (1982) found this argument to be misleading for several reasons:

> First, most cost analyses focus on hardware costs: these costs are not the major factors driving the cost of computer assisted instruction (CAI). Second, technology is more likely to change the skill mix of labor in education than to decrease the intensity of labor. Third, studies of the effectiveness of CAI lead to a policy of integrating the computer with the teacher, not replacing the teacher. And fourth, the cost of replacing a significant portion of teacher time with CAI is currently prohibitive. (p. 1)

Hickey (1975) estimated the cost of CAI lesson preparation to range from 40 to 200 hours of instructor preparation time per hour of presented lesson at an average

cost of $1,000/hour of lesson presented. If one were to amortize over 4 years, estimating 200 students per year, the preparation cost would be approximately $1.25/terminal hour. Given these estimates, it would appear that CAI is efficient only in courses with high student flow. Estimates of the cost of developing an hour of courseware were said to vary between $300 to $3,000 and the cost of CAI delivery varied between $0.40 and $28.50 per student hour (Shavelson & Winkler, 1982). The latter authors attributed the wide variance in cost estimates to the fact that they were made on the basis of many, albeit seldom-stated, assumptions. Furthermore, most cost studies have been conducted independently of effectiveness. As a result of the present review of the literature, it is determined that most studies have made no distinction between time savings and cost effectiveness.

Various formulae have been offered for computing the cost savings and cost effectiveness of self-paced instruction. These methods include provisions for the costs of hardware, courseware, and replacement or maintenance (Holmes, 1982, in a discussion oriented toward would-be implementors; Plocher et al., 1977, in a study of simulation-based electronics courses in the Navy). Nevertheless, there still are not adequate means for computing cost savings associated with time savings. Orlansky and String (1979) suggested that a more meaningful relationship for comparing computer-based instruction with other methods is the cost per student-hour.

Orlansky and String (1979) conducted an extensive study on the cost effectiveness of computer-based instruction (CBI) in military training, consisting of reviewing 30 studies on military training since 1968. Four methods of instruction were distinguished and compared: conventional, individualized, computer-assisted and computer-managed. It was found that student achievement was about the same with all methods, but that CAI and CMI saved approximately 30 percent instruction time. Individualized instruction in the absence of computer support was also found to save student time. In fact, the addition of CAI or CMI to individualized instruction saves little additional student time. Student attrition appeared to increase with CMI compared with conventional instruction, but changes in student quality may have also accounted for this increase. No such data were available on CAI. Students appeared to prefer CAI or CMI to conventional instruction, but the attitudes of instructors (considered in only a few studies) were generally unfavorable.

Orlansky and String pointed out that there are basically two ways to evaluate cost effectiveness: (a) given two systems of the same cost, one would prefer the system with the greater effectiveness, and (b) given two systems of the same level of effectiveness, one would prefer the system that costs less. Orlansky and String further noted that the only worthwhile measure of effectiveness is how well personnel perform in operational units but that all comparisons of the various forms of self-paced instruction against conventional instruction have not used this measure. The measure of effectiveness in operational units has not been used because objective data do not exist. The only data that do exist are subjective opinions of supervisors on how well course graduates perform. Comparisons of effectiveness, as a consequence, have depended on training environment measures such as student test scores, length of time to complete a course, attrition rates, and student and instructor attitudes.

The absence of comprehensive tests at the end of military courses and subsequent lack of data on student retention is a shortcoming in effectiveness research. Based on Orlansky and String's (1979) study of self-paced courses, it can be concluded that

the major interest in the various forms of self-paced instruction in the military has been in the ability of this instructional technology to reduce course length without decreasing achievement. Implicit in this form of cost effectiveness is the assumption that reducing course length will have, in fact, a direct impact on measurable costs. However, Orlansky and String (1979) identified several major problems in getting useful cost data on training whether it is conventional or self-paced. Thus, in addition to a lack of meaningful effectiveness data there is also an apparent lack of meaningful cost data on which to judge the success of any form of alternative instructional technology, such as the forms of self-paced instruction.

Likewise, Zajkowski et al. (1979) noted that a comprehensive assessment of the cost effectiveness/efficiency of individualized instruction in the Navy was not possible without the development of appropriate data and record keeping procedures. While operational costs of courses and the hardware system supporting CMI may be available for some courses, course development costs are generally unavailable. Adequate data on the costs for development of noncomputerized self-paced instruction, as well as costs associated with potential time savings, are not presently available.

Summary

A tenet of the McCombs, Back, and West (1984) conceptualization of factors critical to the success of self-pacing in Air Force technical training is that a self-paced course is successful to the extent that it is perceived to be cost effective (i.e., contributing to cost efficiency and/or quality graduates). Furthermore, this perception is directly influenced by the presence of the management and instructional factors listed in Figure 1. As has been pointed out in this section, there have been considerable difficulties in defining effectiveness and cost parameters and in developing appropriate data on which to base decisions about the cost effectiveness of self-paced instruction. Given this situation, cost effectiveness decisions are more often subjective and based on user perceptions about the efficiency and effectiveness of the self-paced method relative to more traditional approaches.

The literature reviewed in this section generally supports the view that objective cost-effectiveness decisions regarding self-pacing are not possible at the present time. The most definitive publication on the cost effectiveness of self-paced instruction is Orlansky and String's (1979) meta-analysis based on studies of military training. They concluded that not only do inadequate data exist on costs, but that there is also a lack of valid studies on course effectiveness. Most review and empirical articles are in agreement with Orlansky and String (Plocher et al., 1977; Shavelson & Winkler, 1982; Zajkowski et al., 1979).

Orlansky and String did find that individualized instruction, as well as CAI and CMI, saved instruction time, but that computerization did not offer appreciable savings over individualization alone. The need to distinguish time savings from cost effectiveness was noted, however.

CONCLUSIONS

The development of self-paced instruction in the military is inextricably linked with the shift from norm-referenced to criterion-referenced testing and to the implementation of the Instructional Systems Development process. Adequate self-paced instruction requires a complete task analysis, specification of goals and objectives, systematic instructional design and performance-based evaluation.

A successful self-paced instructional program must take student needs into consideration. This includes designing the plan of instruction to meet reading and cognitive abilities, preparation of students in the area of self-responsibility, matching the instruction to learning styles, and orientation of students to the self-paced mode. Consideration should be given in each situation to whether it is feasible to prepare and/or match students according to their needs. The ideal combination of factors may not always be possible.

Several authors have emphasized the importance of the instructor and of group experiences in the self-paced mode. A balanced program of instruction allows adequate opportunity for student-instructor and student-student interactions. The need for interaction is associated with the need for feedback. While some self-paced programs of instruction provide immediate feedback either via programmed text or computer-assisted instruction, there is also a need for instructor and group encouragement and for allowing the students to compare notes on progress and to discuss problems.

A successful self-paced course includes instructors in the decision-making process and makes use of their skills without excessive demands which result in role overload. Also associated with successful implementation of self-pacing are well-defined instructor roles, adequate instructor role training and multilevel staff orientation.

Imposition of a mode of instruction by an outside team is a major factor in the lack of success of self-paced instruction. The implementor and user should be in agreement on project purposes, and in-house personnel should be involved in decision making and curriculum development. There may, however, be a need for outside expertise and for the training of in-house personnel.

Once an innovation is adopted, there is a need for strong management support for its continued application. Studies point to the lack of high level management support as a major factor in the nonsuccess of self-paced instruction in the military.

The ultimate measure of the success of self-paced instruction is whether or not it meets training needs effectively and efficiently. A meta-analysis of the military literature suggests that a determination of cost effectiveness is not possible at this time due to inadequate data on both costs and effectiveness (Orlansky & String, 1979). A valid study of cost effectiveness would require:

1. the use of courses which had been fully implemented and supported by management

2. data on comprehensive student performance and retention at the end of the course as well as on the job (as opposed to block test scores for each segment of instruction)

3. the use of simultaneous conventionally taught courses as control groups

4. data on the cost and amount of instructor time, student time, course developer time, and course maintenance time, for each mode, dormitory, food and supervision costs for students, development costs, hardware costs (if appropriate), and operational costs (pp.88-98)

Studies to date have been limited to block test scores, length of time to complete a course, attrition rates, student and instructor attitudes and field supervisor opinions.

While cost considerations are generally considered important in the decision to adopt, the assumption that cost is negatively related to the adoption and implementation of an innovation was not confirmed by the literature (Tornatzky & Klein, 1981).

Overall, there is a high level of consensus among the military and civilian reports with respect to factors associated with successful implementation of self-paced instruction. Furthermore, the findings based upon this literature review are generally in agreement with results derived from the case studies reported by McCombs, Back, and West (1984). The reader is referred to that report for a more detailed discussion of study findings and recommendations for implementation of self-paced instruction.

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